Advantages of 3D printing for soldiers' clothing and equipment

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3D printing is over a 30-year-old technology. During the past few years, this form of additive manufacturing (AM) technology has strongly risen to the public awareness. Today this technology is becoming a part of everyday life, because printers are easily available. The basic idea of the AM technology is to print different kinds of three-dimensional objects whose geometry is not limited. The main difference between AM printing and traditional manufacturing is that AM printing technology is an additive manufacturing technique and loss of material is thus avoided. Most traditional manufacturing techniques are based on removing material and they need many stages. AM printing technology is suitable for making single parts and small series, but it is not cost-efficient for mass production. Today printing materials in AM are metals, ceramics, glass and plastics. When plastic is used as the material, AM technology is called 3D printing. AM technology is already used in many different industrial areas, for example in metal and jewelry industries and in many applications which are connected to the medical field. For example, it is possible to make human spare parts.

AM process consist of three steps and starts with CAD design, or the object can be scanned to a digital form. Next, the three-dimensional product can be printed with a printer and the final step is the finishing of the product. AM printing is examined a lot and the benefits of the technology are big: quick production, freedom of planning, different kinds of products, unlimited geometry, extremely exact dimensioning of the product, individual products, different kinds of materials can be used in the same product, no material waste, reduction of material costs, and the data file is easy to send and make decentralized production possible. There are also some limitations: material development, properties of materials, lack of standardization and legislation, and the size of printers.

The good fitting of the soldier's clothing and equipment is very important and scanning of soldier is the keyword in 3D printing. People are different and their dimensions differ. Clothes are normally made according to standard measurements and don't necessarily fit well to everybody. Development of structures in 3D printing materials will reduce the weight of clothing and equipment. The core of the clothes could be made as a mass production article, but parts of them could be 3D printed to make them fit perfectly. Printed parts would contain the integrated soldier identity number. The usage of new technology must not hamper the normal use of clothing or equipment. For example, the clothing must be flexible, warm and breathable. The protective vest could be composed of armor plates, which follow the user's body shapes, for the ballistic protection. Shoes or parts of them could be printed to assure perfect fit, because poorly fitting shoes rub easily. 3D printing technology has even been used for making body parts, for example implants. A printing and material technology has been developed for producing a thin artificial skin. It covers the soldier skin on the face and at the same time prevents heat radiation to the enemy's thermographic camera. Skin experiments have already been made with 3D printing and the results have been very promising.

Weight of the clothing and equipment is significant for the soldier's ability to act. Total weight of the equipment can be tens of kilos. 3D printing technology with material development can be used to reduce the accessory weight of the soldier. Lighter materials for example different plastics reduce

the mass and thus the consequent heat load of an individual soldier is reduced. It is easier to move and operate when the clothes and equipment are suitable and appropriately designed. The critical equipment or their parts must be defined, because all the equipment does not necessarily suit well to 3D printing.

The equipment can break on the battlefield and a new one is immediately needed. With 3D printing the equipment can be made only when needed, where needed and in correct size. In many cases temporary spare parts can be printed and used, until the actual spare part is obtained. Storage and transportation costs will be significantly lowered, if one can print spare part or equipment when needed. It is also possible that some parts and equipment are not needed at all. Then manufacturing, storage and delivery costs can be saved. However, the printer and printing materials must be transported and stored. Loss of material can be avoided.

There are some limitations to use of 3D printing in the battlefield. The biggest restrictions apply to the printer: to ensure power supply, serviceability and reliability of the device. The printer can be complicated and everything cannot be printed. Selections of printing materials and sizes of printers are limited. It is possible to mix different materials to improve properties of equipment. Database of all soldiers is also needed.

3D Printing technology is widely researched and development will go on. It is possible to use it in different kinds of applications and complicated structures. Material development is a very important part of the 3D printing technology. In the future, increasingly more versatile and advanced materials will be created, which might be suitable for new kind of applications. 3D printing technology has many advantages, for example personal fitting, light materials, and small storages to facilitate the equipment maintenance of the soldier in the battle field. Power supply, printing materials, serviceability, and the reliability of the devices are the biggest limitations of technology. 3D printed products should be estimated regularly on the basis of the development of the technology and materials, and also for the obtained results.